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IN MISSISSIPPI POST STUDY
(1977 Progress Report).

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SUMMARY

To evaluate the effectiveness of various wood preservatives, service records of treated southern yellow pine fenceposts installed on the Harrison Experimental Forest, Saucier, Miss., have been compared periodically since 1936.

In contrast to the 3.3 years average life of the untreated control posts, nine preservatives, after approximately 37 years, have had less than 60 percent of their posts fail and indicate an average life of well over 30 years.

Two groups of treated posts installed in 1949 have failed completely: No. 2 distillate with an average life of 6.2 years and Wyoming residual with an average life of 9.0 years. Preservatives performing better in this installation include 12 groups with no failures after 27 years and 19 groups with over 10 percent failures, permitting estimated average life values of 25 to 42 years.

Only one treated post installed in 1964 has failed.

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COMPARISON OF WOOD PRESERVATIVES IN MISSISSIPPI POST STUDY¹ (1977 Progress Report)

By

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INTRODUCTION

During late 1936 and early 1937, the U.S. Forest Products Laboratory, in cooperation with the Southern Forest Experiment Station and the then-existing Bureau of Entomology and Plant Quarantine, started a service test at the Harrison Experimental Forest, Saucier, Miss., on posts treated with 24 wood preservatives. A report by Wirka³ contained a description of the preservatives and treatments used in the original installation of posts in a line approximately 8 miles long. This report also described the installation and presented the results of the test after 3 years of service.

Additional posts were added to this line during the years 1938 and 1941. A report by Blew⁴ in 1947 described those additions and presented the conditions of all posts in the 8-mile line after approximately 5-1/2 to 10 years of service.

During April and May 1949, the study was expanded to include posts treated with 44 preservatives and untreated controls that were installed in a plot on the Harrison Experimental Forest.

¹ This note is a continuation of regular progress reports under the same general title, issued 1950-1962 as Forest Products Laboratory Report No. 1757 and since 1963 as USDA Forest Service Research Note FPL-01.

² Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

³ Wirka, R. M. Comparison of Preservatives in Mississippi Fence-Post Study. Proceedings of the American Wood-Preservers' Association, vol. 37, pp. 365-379. 1941.

⁴ Blew, J. O. Comparison of Preservatives in Mississippi Fence-Post Study After 10 Years of Service. Proceedings of the American Wood-Preservers' Association, vol. 43, pp. 26-41. 1947.

During December 1964, another plot installation was added to include posts treated with 15 preservatives and untreated control posts of longleaf pine. Various commercial companies cooperated in this work by furnishing the preservatives and by contributing to the cost of making the treatments and of installing test posts.

Periodic progress reports issued since 1950 have described the conditions of these posts.

This progress report deals mainly with the posts installed in plots in 1949 and 1964.

POSTS

All of the posts used in this study were of round southern pine that consisted mostly of sapwood. All posts were sound and showed no indication of decay. Those treated for the 1949 and 1964 installations, however, were carefully selected for freedom from infection by mold or stain fungi. Those treated in 1941 by double-diffusion were cut and treated while green, at the Harrison Experimental Forest. All other posts for the 1936-1941 and 1949 installations were cut at McNeill, Miss., and were shipped to the Laboratory for treatment. Most of the posts were peeled, sprayed with stain-control chemical, and either air-dried before shipment (in the case of the 1936 installation) or shipped green and kiln- or air-dried at the Laboratory (in the case of the 1949 installation).

The posts installed in the line from 1936 to 1941 were 7 feet in length and from 2-1/2 to 7 inches in top diameter. Those installed in the plot during 1949 were of long-leaf pine 6 feet in length and from 2.8 to 5.3 inches in top diameter. Many of them required repeeling, before treatment, to remove inner bark. The different diameter sizes were distributed as uniformly as practicable to each of the treatments used in the study.

The posts pressure-treated for the 1964 installation were of longleaf pine cut near Brewton, Ala., machine peeled, and promptly kiln-dried before shipment to the Laboratory. These posts were approximately 4 inches in top diameter and 6 feet in length. The 1964 posts treated by double-diffusion were also of longleaf pine, cut near Brewton, but shipped without drying or peeling.

INSTALLATION OF POSTS

The posts, at the start of the test in late 1936, were set in a line approximately 8 miles long on the Harrison Experimental Forest, Saucier, Miss. The posts were grouped into 100 units, each of which included one post of the different treatments selected at random, and, for the most part, one untreated control post. It was possible to install only

65 untreated posts when the treated posts were installed; the remaining 33 were set during November and December 1938. The position of the treated posts and of the untreated control post within each unit was also randomized.

During 1941, two additional treatments were added to this line, with one post from each treatment being installed in each of the 100 units. The line installation was originally designed so that about 70 percent of the posts of each treatment were set on the drier, well-drained sites of the area (pine hills or dry hardwood sites), 20 percent in moist soil (pitcher-plant areas or any area with fluctuating water table), and 10 percent in swamp or standing water.⁵ A careful check during several post inspections, which included both extremes of dry and wet weather, indicated that the segregation according to dry, damp, and wet sites varied slightly with the different treatments but was generally about 65 percent, 18 percent, and 17 percent, respectively.

In the line, 100 posts were originally installed for each preservative or treatment. The number of test posts has since been reduced by fire loss and pilferage, or by other removals not occasioned by decay or termite attack.

The posts in the two more recent installations on the Harrison Experimental Forest were set in plots on a comparatively dry site during April, in early May 1949, and during December 1964 (fig. 1). Twenty-five posts were installed for each treatment, along with 25 untreated control posts. These posts were installed in plots by the randomized block method, by which the plot was divided into 25 blocks, each containing one post from each treatment and one untreated control post, selected at random. The posts were set 3 feet apart in rows, and the rows were 3 feet apart in the blocks.

The soil in the general area of Saucier, Miss., is reported to be a Norfolk fine sandy loam. In the plot of posts installed during 1949, the soil pH is 4.98 to 5.04. The average annual rainfall in the test area is 60 inches and the growing season is 276 days.

Preservatives and Treatment

Preservatives used are shown in tables 1, 2, and 3. Table 1 includes 11 preservatives or treatments and also untreated control posts set in the 8-mile line from 1936 to 1941.

⁵ Throughout the report these sites will be referred to as "dry," "damp," and "wet," although these terms are relative and apply only to the Mississippi test area.

Forty-four preservatives or treatments and untreated control posts are included in table 2 for the posts set in the plot during 1949.

Fifteen preservatives, one applied by double diffusion and 14 by pressure impregnation, were included with untreated control posts in the 1964 plot installation and are shown in table 3.

The posts in the 8-mile line (with the exception of the untreated control posts and one group treated by double-diffusion) and the posts in the 1949 installation (with the exception of the untreated control posts) were all treated by pressure impregnation. The oil preservatives were applied by the Rueping empty-cell process, and the waterborne preservatives were applied by the full-cell process.

Minimum, maximum, and average preservative retentions, and standard deviations, are shown in tables 1 and 2. Average retentions of preservative by weight and by assay are reported in table 3. The lower standard deviations, which indicate greater uniformity of treatment in table 2, are attributed to the practice of discarding any post that showed blue stain or mold growth. Borings taken from posts following each pressure treatment showed for the most part either complete or nearly complete sapwood penetration. The exception noted was the lignite coal-tar creosote pressure treatment for the 1936 installation; a high percentage of these posts showed less than complete sapwood penetration.

RESULTS TO DATE

During any inspection each post was pushed with a force at which it could usually be expected to break off if decay or termite attack had progressed to a critical point. If the post broke off, the cause of the failure was determined. If not, the post was considered serviceable.

Posts Installed From 1936 to 1941

The condition of the posts installed from 1936 to 1941 with less than 60 percent failure is shown in table 1 and discussed in the following paragraphs according to preservatives and treatments used.

Acid copper chromate.--Acid copper chromate (ACC) is prepared from copper sulfate and sodium dichromate in an acid solution. Approximately 38 percent of the posts treated with this preservative have been removed mostly because of decay. The estimated average life of the 77 test posts is 42 years. The average retention of the removed posts was 0.46 pound per cubic foot (pcf) (oxide basis), the same retention as the average of the total posts installed. The percentages of posts removed were 46, 21, and 27 for dry, damp, and wet sites respectively. Removals to date have been as follows:

Years after installation	1	3	4	5	9	12	16	19	20	21	22	24	28	33	37
Number (cumulative) removed	1	2	3	5	6	7	9	10	12	15	17	19	21	27	29

Coal-tar creosote.--Coal-tar creosote (Grade 1) was formerly American Wood-Preservers' Association (AWPA) Standard 4 e-grade. Forty-six percent of the posts treated with this preservative have failed, mostly because of decay. The estimated average life of the posts is 41 years. Failed posts had an average preservative retention similar to the 6 pcf average of the installation. Forty-six percent of the posts were removed from dry sites, 71 percent from damp sites, and 13 percent from wet sites. Removals to date are as follows:

Years	13	15	17	18	19	20	21	22	23	24	25	27	28	30	33	37
Number	1	2	3	4	5	7	10	13	15	17	18	20	24	27	35	40

Coal-tar creosote 50 percent and used crankcase oil 50 percent.--Thirty-three percent of the posts treated with an average of 4.8 pcf of 50-50 solution of creosote and crankcase oil failed, mostly because of decay, with an estimated average life of 44 years. Twenty-three posts have been removed from dry areas, four from damp sites, and one from a wet site. Removals to date are as follows:

Years	12	17	19	20	24	25	26	28	30	33	37
Number	1	5	6	7	10	11	12	13	15	19	28

Lignite coal-tar creosote.--Fifty-eight percent of the posts treated with lignite coal-tar creosote have failed, principally because of decay or combined decay and termite attack. The estimated average life of the 96 posts is 38 years. The average retention of preservative for the 56 posts removed was 3.9 pcf, considerably less than the 6.3 pcf for the posts installed. Sixty-six percent of the posts installed in dry areas have been removed; 41 and 47 percent, respectively, have been removed from the damp and wet sites. Removals to date are as follows:

Years	3	5	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Number	1	2	3	7	8	10	11	14	18	20	23	26	28	30	32	36
Years	21	22	24	26	27	28	30	33	37							
Number	38	40	42	44	46	48	50	55	56							

Pentachlorophenol 4.82 percent (by weight) in used crankcase oil.--Ten posts treated with this preservative were removed from dry and one from damp areas during 37 years of service, 6 for decay and 5 for combined decay and termite attack. These posts were treated with an average solution retention of 5.6 pcf. Removals to date are as follows:

Years	17	30	33	37
Number	1	3	7	11



Figure 1.--Test posts installed during 1949 in a plot at the Harrison Experimental Forest, Saucier, Miss.

Pentachlorophenol 3.02 percent in used crankcase oil.--Twenty-eight percent of the 80 posts treated with this solution have been removed. All but one were removed from dry sites. The estimated average life of the test posts is 46 years. The average retention of preservative in the 22 posts removed was 4.7 pcf, which is lower than that of 6.4 pcf for the posts installed. Removals are as follows:

Years	8	13	19	24	25	26	27	28	30	33	37
Number	1	2	3	4	6	7	9	13	15	17	22

Tetrachlorophenol 2.9 percent in used crankcase oil.--Fifty-one percent of the posts treated with 2.9 percent tetrachlorophenol in used crankcase oil have failed because of decay or combined decay and termite attack. The estimated average life of the 86 posts in test is 39 years. The 44 posts removed had an average solution retention of 7.4 pcf; that for the installation was 7.1 pcf. These removed posts constituted 68 percent of those installed in dry areas, 21 percent of those in damp sites, and 13 percent of those in wet sites. Removals to date are as follows:

Years	11	12	13	14	15	17	18	19	20	22	23	26	28	30	33	37
Number	1	2	3	4	5	6	9	10	12	17	18	20	24	27	35	44

Tetrachlorophenol 4.83 percent in used crankcase oil.--Forty-eight percent of the posts treated with 4.83 percent of tetrachlorophenol in used crankcase oil have failed. Sixty-nine percent of those installed in dry sites, 12 percent from damp, and 7 percent from wet sites have failed because of decay or decay and termite attack. The estimated average life of the 89 posts in test is 40 years. The average solution retention of the failed posts was 5.6 pcf. Removals to date are as follows:

Years	18	19	20	21	22	23	24	26	28	30	33	37
Number	2	3	4	6	8	10	13	14	15	19	33	43

Water-gas tar.--Approximately 39 percent of the posts treated with water-gas tar have failed because of decay and combined decay and termite attack. The average life of the 84 test posts is estimated to be 42 years. Forty-two percent of the posts installed in dry sites failed, thirty-six percent of the posts failed in damp sites, and 35 percent in the wet sites. The average preservative retention of the 33 failed posts was 4.7 pcf as compared with the average of 6.3 pcf for the installation. Removals to date are as follows:

Years	14	16	19	20	21	22	23	24	25	26	27	28	30	33	37
Number	1	2	4	6	7	8	9	10	11	12	14	15	18	27	33

Zinc meta arsenite.--Zinc meta arsenite is prepared from arsenious acid, zinc oxide, and acetic acid. Fourteen posts of the 88 in test treated with an average retention of 0.44 pcf of this preservative have failed -- seven posts from dry sites, one from a damp site, and six from wet sites. Removals to date are as follows:

Years	20	22	27	30	33	37
-------	----	----	----	----	----	----

Number	1	2	3	4	12	14
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Copper sulfate and sodium arsenate applied by double diffusion.--Eleven posts treated with copper sulfate and sodium arsenate applied by double diffusion have failed because of decay or combined decay and termite attack after nearly 34 years of service. Nine were located in dry sites and one each in damp and wet sites. Removals to date have been as follows:

Years	12	16	18	20	26	29	33
-------	----	----	----	----	----	----	----

Number	1	2	4	5	6	8	11
--------	---	---	---	---	---	---	----

The posts in the 8-mile line that have completely failed or have had more than 60 percent removals are briefly summarized as follows:

(1) Average life of 10 to 12 years (100 pct failure). Posts treated with 6.2 pounds per cubic foot of 5 percent beta-naphthol in organic solvent: 0.92 pound per cubic foot of borax-boric acid (50-50), or 0.34 pound per cubic foot of Osmoplastic at the groundline and on the top end.

(2) Estimated life of 8 to 21 years. Pressure-treated with 10 percent of coal-tar creosote and 90 percent of used crankcase oil; crankcase oil alone; hardwood-tar creosote (No-D-K); phenyldichlorarsine (P.D.A.); sodium dichromate; and sodium chromate.

(3) Estimated life of 25 to 40 years. Pressure-treated with chromated zinc chloride; coal-tar; fluor chrome arsenate phenol-type A (FCAP-A); and zinc chloride; steeping in mercuric chloride; and full-length Osmose (diffusion) treatment.

(4) Untreated control posts. The average life of the untreated control posts set from late 1936 to December 1938 was 3.3 years. The posts installed in well-drained comparatively dry soil had an average life of 2.6 years, and failed mostly because of decay and termite attack. Those installed in moist soil and in swamps or standing water had an average life of 4 and 4.8 years, respectively, and failed mostly because of decay. Some of the posts set in water remained serviceable for more than 5 years and failed mainly because of top decay.

Condition of Posts Installed in 1949

General information on the composition of the preservatives used in the pressure treatment of the posts installed in 1949 is given in table 2. That table also shows the condition of the test posts at the December 1976 inspection.

All of the untreated control posts failed during approximately 3-1/2 years of service. Their average life was 2.3 years. Failures were mostly because of combined decay and termite attack. Removals were as follows:

Years after installation	1-1/2	2-1/2	3-1/2
Number (cumulative) removed	13	20	25

Two hundred-nineteen treated posts failed mostly because of decay or combined decay and termite attack after approximately 27-1/2 years of service. All of the posts treated with No. 2 (fuel oil) distillate petroleum oil and Wyoming residual (used generally for blending with creosote) have failed, with average life values of 6.2 years and 9.0 years, respectively. The number (cumulative) removed by year and the preservative is given in table 4 for the posts installed in 1949.

Condition of Posts Installed in 1964

Data in table 3 show all but one of the treated posts serviceable after 12 years. The untreated control posts have failed because of decay or decay and termite attack with an average life of 3.6 years.

SUMMATION OF RESULTS

A summary of the information obtained during the 39 years since the beginning of this study follows:

(1) The failures, to date, of treated and untreated posts (set 1936 to 1941) on the basis of posts installed under the three site conditions occurred earlier in the dry and damp areas than in swamps.

(2) The untreated posts installed during 1937 and 1938 had an average life of 3.3 years. The untreated posts set in well-drained, comparatively dry soil failed because of combined decay and termite attack after an average life of 2.6 years. Those set in damp soil (outside of swamps) failed mostly because of decay after an average life of 4.0 years. The posts set in swamps also failed mostly because of decay and lasted an average of 4.8 years. The untreated control posts set in 1949 in a dry site had an average life of 2.3 years and those set in a similar site in 1964 had an average life of 3.6 years.

(3) Treated posts installed in the 8-mile line have estimated average life values of from 8 to over 50 years.

Posts treated with the following preservatives have estimated life values of 8 to 21 years with the retentions used: 6.2 pounds per cubic foot of 5 percent beta-naphthol in organic solvent, 0.92 pound per cubic foot of borax-boric acid (50-50), Osmoplastic treated with an average of 0.34 pound per cubic foot (at the groundline and on the top end), used crankcase oil, 10 percent creosote and 90 percent used crankcase oil, hardwood-tar creosote (No-D-K), phenyldichlorarsine (P.D.A.), sodium dichromate, and sodium chromate.

Average life values of 20 to 30 years are estimated for posts pressure treated with chromated zinc chloride, coal tar, FCAP-A, and zinc chloride; steeping in mercuric chloride; and full-length Osmose (diffusion).

Posts treated with preservatives described in table 1 with estimated average life values of over 50 years include: Pentachlorophenol in used crankcase oil, zinc meta arsenate, and copper sulfate plus sodium arsenate (double diffusion). All the preservatives described in table 1 have given estimated average life values of over 30 years.

(4) Of the treated posts installed in 1949, all treated with No. 2 fuel oil and Wyoming residual petroleum have failed with average life values of 6.2 and 9 years, respectively.

For the following, failures have exceeded 10 percent and average life is estimated to be from 25 to 42 years:

Type	Years
Ammoniacal copper arsenate	42
Copperized chromated zinc chloride	29
Chromated zinc chloride, F.R.	39
Coal-tar creosote, straight run, low residue	37
Coal-tar creosote, straight run, medium residue	40
Coal-tar creosote, medium residue, low in fraction from 235° to 270° C, crystals removed	40
Coal-tar creosote, low temperature	40
Lignite coal-tar creosote	30
Oil-tar creosote (Gasco)	37
Softwood-tar creosote (Termiteol)	27
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50 percent, and petroleum oil (No. 2 distillate) 50 percent (by volume)	34
Lignite creosote-petroleum (50-50)	30
Copper naphthenate (0.5 pct)-petroleum	42
Pentachlorophenol (0.5 pct)-petroleum oil (No. 2 distillate)	42
Pentachlorophenol (0.5 pct)-petroleum oil (Wyoming residual)	36
Highly aromatic (S.O.) petroleum oil	25
Aromatic, low residue (S.W.) petroleum oil	40
Highly aromatic high residue (S.O.) petroleum oil	26
No. 4 aromatic residual (California) petroleum oil	33

With the other preservatives used in treatment of the posts for the 1949 installation, failures either have not occurred or are less than 10 percent, so an estimate on average life cannot be given.

One treated post failed from the 1964 installation after 8 years of service. The average life of the untreated controls was 3.6 years.

Table 1.--Condition of round southern yellow pine experimental fenceposts on the Harrison Experimental Forest, Saucier, Miss., after about 34 to 38 years of service (treated posts were installed from late in 1936 to May 1941)

34 to 50 years of service

Preservative	Posts in test ¹	Form of preservative	Retention of preservative ^{2,3}			Standard deviation	Method of treatment	Condition of posts November 1974			Total removed	Average life ⁴
			Minimum	Maximum	Average			Serviceable	Removed because of--	Decay; Decay; Termites		
			Pcf	Pcf	Pcf			Pct	Pct	Pct	Number	Yr
Posts set late in 1936 to February 1937												
Acid copper chromate (ANFA P5)	77	Salt	0.75 (0.38)	1.05 (0.53)	0.92 (0.46)	0.08	Pressure	62	33	5	29	38 : 42
Coal-tar creosote, grade 1	88	Oil	1.90	8.60	6.00	1.50	do.	55	28	16	1	40 : 46 : 41
Coal-tar creosote, 50 pct used crankcase oil,	84	Solution	1.60	14.80	5.40	2.20	do.	67	20	12	1	28 : 33 : 44
50 pct (by volume)	96	Oil	1.10	11.60	6.30	3.20	do.	40	25	30	3	58 : 36
Lignite coal-tar creosote												
Pentachlorophenol, 4.82 pct (by weight) in used crankcase oil	90	Solution	2.90	9.50	6.70	1.60	do.	88	7	5	11	12 : Over 50
Pentachlorophenol, 3.02 pct (by weight) in used crankcase oil	80	do.	3.10	11.40	6.40	1.80	do.	72	18	9	1	22 : 28 : 46
Tetrachlorophenol, 2.9 pct (by weight) in used crankcase oil	87	do.	1.20	16.10	7.10	3.10	do.	49	41	10	44	51 : 39
Tetrachlorophenol, 4.83 pct (by weight) in used crankcase oil	89	do.	3.50	9.40	5.80	1.50	do.	52	29	19	43	48 : 40
Water-gas tar	84	Oil	1.20	19.00	6.30	3.00	do.	61	24	15	33	39 : 42
Zinc meta arsenite	88	Salt	.25 (.27)	.54 (.59)	.42 (.46)	.06	do.	84	11	5	14	16 : Over 50
Untreated posts (set February 1937)	65	--	--	--	--	--	None	--	3	94	3	65 : 100 : 3.1
Posts set in 1938 and 1941												
Untreated posts (set November, December 1938)	33	--	--	--	--	--	None	--	33	64	3	33 : 100 : 3.7
Copper sulfate and sodium arsenate (set May 1941)	87	Salt	--	--	.35 (.11)	--	Double diffusion	87	10	3	--	11 : 13 : Over 50

¹ Installation included 100 posts for each treatment. This number has since been reduced in some cases by fire and pilferage.

² Based on the 100 posts treated in each group, unless otherwise indicated.

³ Retention values in parentheses are based on preservative oxides.

⁴ Average life of all untreated posts is 3.3 yr; average life is shown where all posts have been removed. Other values are estimates taken from a mortality curve or based on test time when 60 pct of posts have failed. Where percentage of posts removed is 10 pct or less, no estimate on average life is given.

Table 2.--Condition of round longleaf pine experimental posts on the Harrison Experimental Forest, Saucier, Miss., after about 27-1/2 years of service. (All treatments by pressure impregnation. Posts were installed during April and May 1949.)

Preservative	Posts in test	Retention of preservative ¹				Condition of posts December 1976				Average life
		Form of preservative	Minimum	Maximum	Average	Standard deviation	Serviceable	Removed because of--	Total removed	
								Decay	Termites	
							Pct	Pct	Pct	Yr
Ammoniacal copper arsenate (AWPA-P5)	25	Dry salt	0.30 (0.32)	0.39 (0.42)	0.34 (0.37)	0.029	88	12	--	42
Boliden salt B (ZnO + H ₃ AsO ₄ + CrO ₃)	25	do	.43 (.38)	.57 (.50)	.50 (.44)	.035	100	--	--	--
Chromated zinc arsenate (Boliden salts)	25	do	.65 (.43)	.76 (.50)	.70 (.46)	.029	96	4	--	4
Chromated zinc chloride, copperized (ZnCl ₂ + Na ₂ CrO ₇ + 2H ₂ O + CuCl + 2H ₂ O)	25	do	.89 (.53)	1.06 (.64)	.98 (.59)	.055	48	52	--	29
Chromated zinc chloride, FR (ZnCl ₂ + Na ₂ Cr ₂ O ₇ + 2H ₂ O + H ₃ BO ₃ + (NH ₄) ₂ SO ₄)	24	do	2.71	3.59	3.25	.254	83	17	--	39
Creosotes:										
Coal-tar creosotes:										
Straight run, low residue	25	Oil	4.6	7.5	5.9	.903	80	12	8	37
Straight run, medium residue	25	do	4.2	7.7	5.6	.899	84	8	8	40
Straight run, high residue	24	do	4.9	7.5	6.0	.873	96	--	4	4
Medium residue, low in tar acids	25	do	4.6	6.9	5.7	.638	100	--	--	--
Medium residue, low in naphthalene	25	do	5.2	7.1	6.1	.519	96	4	--	4
Medium residue, low in tar acids and naphthalene	25	do	4.8	7.6	6.0	.701	100	--	--	--
Low residue, low in tar acids and naphthalene	24	do	5.3	6.9	6.0	.516	92	--	8	8
High residue, low in tar acids and naphthalene	25	do	5.4	6.8	6.1	.399	100	--	--	--
Medium residue, low in fraction from 235° to 270° C, crystals removed	25	do	5.1	7.0	6.1	.591	84	12	4	16
High residue, crystals removed	25	do	5.1	6.8	6.0	.528	96	--	4	4
Low temperature	25	do	5.5	6.9	6.3	.401	84	12	4	16
English, vertical retort	25	do	5.0	6.9	6.3	.552	92	8	--	8
English, coke oven	25	do	4.5	7.4	6.0	.715	100	--	--	--
Coal-tar creosote (Carbosota)	25	do	5.2	6.9	6.0	.593	96	4	--	4
Lignite coal-tar creosote	25	do	5.1	6.8	6.3	.518	52	40	8	48
Oil-tar creosote (Gasco)	25	do	5.1	6.8	5.9	.616	80	16	4	20
Softwood-tar creosote (Termiteol)	25	do	4.9	6.9	6.2	.505	32	44	24	68
Creosote solutions:										
English, vertical retort 50 pct and coke oven 50 pct (by volume)	25	Solution	5.2	6.8	6.0	.489	92	4	4	8
Medium residue (low in tar acids and naphthalene) with 2-1/2 pct pentachlorophenol (by weight)	25	do	5.1	6.9	6.0	.594	100	--	--	--
Coal-tar creosote 70 pct, and coal-tar 30 pct (by volume)	24	do	5.2	6.9	6.1	.574	100	--	--	--
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50 pct, and petroleum oil (No. 2 distillate) 50 pct (by volume)	24	do	5.2	6.8	5.9	.418	71	21	8	29
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50 pct, and petroleum oil (Wyoming residual) 50 pct (by volume)	25	do	5.2	6.9	6.0	.497	92	8	--	8

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Table 2.--Condition of round longleaf pine experimental posts on the Harrison Experimental Forest, Saucier, Miss., after about 27-1/2 years of service. (All treatments by pressure impregnation. Posts were installed during April and May 1949).--continued

Preservative	Posts: in	Retention of preservative ¹				Condition of posts December 1976							Average life ²
		test form	Minimum	Maximum	Average	Stand- ard devia- tion	Service- able	Removed because of	Total removed	Decay: Ter- mites	Decay: Ter- mites	Yr	
			Pct	Pct	Pct		Pct	Pct	Pct	Pct	Num- ber	Pct	
Creosote solutions:--continued													
Coal-tar creosote (medium residue, low in tar acids and naphthalene) 50 pct, and petroleum oil (Wyoming residual) 50 pct (by volume); fortified with 2-1/2 pct pentachlorophenol (by weight of total solution)	25	Solution	5.3	6.7	6.0	0.453	92	8	--	--	2	8	--
Lignite coal-tar creosote, 50 pct and coal-tar creosote (medium residue, low in tar acids and naphthalene), 50 pct (by volume)	25	do	5.6	6.9	6.3	.376	100	--	--	--	--	--	--
Lignite coal-tar creosote, 50 pct and petroleum oil (Wyoming residual), 50 pct (by volume)	25	do	5.5	7.1	6.4	.440	52	36	12	--	12	48	30
Oil-tar creosote (Gasco) with 2 pct penta by weight	24	do	5.3	6.8	5.8	.455	100	--	--	--	--	--	--
Copper naphthenate, 0.5 pct copper-metal equivalent (by weight) in petroleum oil (No. 4 aromatic residual)	25	do	5.2	6.9	6.0	.540	88	8	4	--	3	12	42
Pentachlorophenol:													
5 pct (by weight) in petroleum oil (No. 2 distillate)	25	do	5.1	7.0	6.3	.531	88	4	4	4	3	12	42
5 pct (by weight) in petroleum oil (No. 4 aromatic residual)	25	do	5.3	7.0	5.9	.482	100	--	--	--	--	--	--
3 pct (by weight) in petroleum oil (No. 4 aromatic residual)	25	do	5.3	6.9	6.0	.412	100	--	--	--	--	--	--
5 pct (by weight) in petroleum oil (Wyoming residual)	25	do	4.5	7.4	6.0	.817	76	20	4	--	6	24	36
Pentachlorophenol, 5 pct in petroleum oil (No. 4 aromatic residual), 50 pct; and copper naphthenate, 0.5 pct copper-metal equivalent, in petroleum oil (No. 4 aromatic residual), 50 pct (by volume)	25	do	5.4	7.0	6.2	.543	100	--	--	--	--	--	--
Petroleum oil:													
Aromatic, high residue (S.W.)	25	Oil	5.1	6.7	6.1	.553	92	8	--	--	2	8	--
Aromatic, low residue (S.W.)	25	do	5.1	6.9	6.1	.557	84	4	12	--	4	16	40
Highly aromatic (S.O.)	24	do	5.1	6.9	6.0	.484	25	63	12	--	18	75	25
Highly aromatic, high residue (S.O.)	24	do	5.1	6.9	6.1	.503	29	54	17	--	17	71	26
No. 2 distillate (Mid-United States)	25	do	5.0	7.2	5.9	.650	--	36	64	--	25	100	6.2
No. 4 aromatic residual (California)	25	do	5.2	6.8	5.9	.448	68	28	4	--	8	32	33
Wyoming residual	25	do	5.1	6.9	5.8	.691	--	84	16	--	25	100	9.0
Untreated control posts	25	--	--	--	--	--	--	20	80	--	25	100	2.3

¹ Retention values in parentheses based on preservative oxides.

² Average life is shown where all posts have been removed. Other values are estimates taken from a mortality curve or based on test time when 60 pct of posts have failed. Where percentage of posts removed is 10 pct or less, no estimate on average life is given.

³ Post eliminated from test, hit by falling tree.

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Table 3.--Condition of round longleaf pine posts on the Harrison Experimental Forest, Saucier, Miss., after about 12 years of service (posts installed December 1964)

Preservative	Posts:	Retention of		Condition of posts				Total	Average	
	in	preservative (average)		December 1976				removed	life	
	test	By weight ¹	By assay ²	Service-able	Removed because of--					
					Decay	Decay and termites	Termites			
		Pcf	Pcf	Pct	Pct	Pct	Pct	Num-ber	Pct	Yr
Ammoniacal copper arsenate (AWPA P5)	25	0.52 (0.50)	(0.52)	100	--	--	--	--	--	--
Chromated copper arsenate--										
Type I (Fed. Spec. TT-W-550)	25	.73 (.44)	(.50)	100	--	--	--	--	--	--
Type I modified (Wolmanac)	25	.70 (.43)	(.54)	100	--	--	--	--	--	--
Type II (Fed. Spec. TT-W-550)	25	.41 (.37)	(.44)	100	--	--	--	--	--	--
Tanalith C	25	.71 (.44)	(.58)	100	--	--	--	--	--	--
Tanalith NCA	25	.65 (.48)	(.64)	100	--	--	--	--	--	--
Copper-8-quinolinolate, 1.0 pct (10 pct solubilized AWPA P8) in heavy (AWPA P9) petroleum oil	25	8.1	.12 (Copper-8)	100	--	--	--	--	--	--
Copper chlorophenol (KP) (copper oxide and chlorophenol in ammoniacal solution)	25	.35 (.37)	.57	96	--	4	--	1	4	--
Creosote, coal-tar (AWPA P1)	25	8.3	8.6	100	--	--	--	--	--	--
Fluor chrome arsenate phenol--type A (AWPA P5)	25	.66 (.40)	(.41)	100	--	--	--	--	--	--
Pentachlorophenol, 5 pct in heavy (AWPA P9--Am Petrofina) petroleum oil (AWPA P8)	25	7.9	.43 (Penta)	100	--	--	--	--	--	--
Pentachlorophenol, 5 pct in heavy (AWPA P9--Shell oil) petroleum oil (AWPA P8)	25	8.4	.48 (Penta)	100	--	--	--	--	--	--
Pentachlorophenol, 5 pct and Shellwax, 10 pct in heavy (AWPA P9--Shell oil) petroleum oil (AWPA P8)	25	8.1	.43 (Penta)	100	--	--	--	--	--	--
Petroleum oil, heavy (AWPA P9--Am Petrofina)	25	8.4	--	100	--	--	--	--	--	--
Copper sulfate and sodium chromate-sodium arsenate (double-diffusion treatment)	25	--	³ (.47) (.27)	100	--	--	--	--	--	--
Untreated	25	--	--	--	16	84	--	25	100	3.6

¹ Retention values in parentheses are based on preservative oxides.

² Composite sample of 3/8-in.-diameter plugs from outer inch of 10 extra posts treated in same charges with test posts.

³ Average determined from analysis of composite sample from sections of 5 sample posts not installed.

Table 4.--Yearly failure (cumulative) of the treated posts set in 1949

Preservative	Years after installation																					
	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	17.5	19.5	21.5	23.5	25.5	27.5	
Ammoniacal copper arsenate (ANPA P5)																	1	1	3	3	3	
Chromated zinc arsenate (Boliden salts)						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Chromated zinc chloride																						
Copperized FR	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	6	6	6	12	13	13	
Creosotes:																						
Coal-tar creosotes:																						
Straight run																			1	1	5	
Low residue																1	1	2	3	3	4	
Medium residue																			1	1	1	
High residue																						
Medium residue, low in naphthalene																1	1	1	1	1	1	
Low residue, low in tar acids and naphthalene															1	1	1	1	2	2	2	
Medium residue, low in fraction 235° to 270° C, crystals removed									1	1	1	1	2	3	3	3	3	3	4	4	4	
High residue crystals removed																					1	
Low temperature																					4	
English vertical retort:																			1	1	2	
Coal-tar creosote (Carbosote)																					1	
Lignite coal-tar creosote																					1	
Oil-tar creosote (Gasco)												1	1	3	3	3	5	6	8	10	12	
Softwood-tar creosote (Termitool)											1	1	1	2	6	6	9	9	13	14	17	
Creosote solutions:																						
English vertical retort, 50 pct. and coke oven, 50 pct. (by volume)																				2	2	
Coal-tar creosote (medium residue, low in tar acids and naphthalene)																						
50 pct. and petroleum oil (No. 2 distillate), 50 pct. (by volume)																			1	4	10	
Coal-tar creosote (medium residue, low in tar acids and naphthalene)																						
50 pct. and petroleum oil (Wyoming residual), 50 pct. (by volume)																			1	1	2	
Coal-tar creosote (medium residue, low in tar acids and naphthalene)																						
50 pct. and petroleum oil 50 pct. fortified with 2-1/2 pct pentachlorophenol																					2	
Lignite creosote-petroleum (50-50)							1	1	1	2	2	2	2	2	2	3	5	5	6	7	12	
Copper naphthenate, 0.5 pct. copper												1	1	1	1	1	1	1	3	3	3	
Pentachlorophenol:																						
5 pct. (by weight) in petroleum oil (No. 2 distillate)																			1	2	3	
5 pct. in petroleum oil (Wyoming residual)													1	1	1	1	4	5	5	5	6	
Petroleum oil:																						
Aromatic, high residue (S.W.)																					2	
Aromatic, low residue (S.W.)																						
High aromatic, high residue (S.O.)			1	1	1	1	1	1	1	2	2	2	3	4	4	5	8	10	11	12	17	
Highly aromatic (S.O.)													1	1	2	4	6	12	15	17	18	
No. 2 distillate		1	7	11	17	19	21	22	22	22	23	24	24	24	24	25	25	25				
No. 4 aromatic residual (California)						1	1	1	1	1	1	1	1	1	1	3	3	4	6	6	8	
Wyoming residual	1	2	6	7	9	11	13	16	16	18	18	19	20	20	21	23	25	25				

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